Analyzing Students' Perceptions of Engineering Leadership Skills Trainings through Guest Lectures in a Capstone Course

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Keywords: Leadership Skills; Guest Lectures; Student Engagement

Abstract

While industry, faculty, and students alike recognize the need for leadership education in undergraduate courses, there is still a gap between the students' experience in applying these skills and industry expectations. In academia, these skills are typically measured during team-based senior design courses. Courses may invite guest speakers to provide a wide perspective of successful leadership. The assumption is that students will appreciate this diversity, thus helping them remember, understand and apply the lessons. This study provides an analysis of how a group of students valued these types of trainings with respect to three categories: the course objectives, their upcoming professional careers, and their personal lives. The students are surveyed after each of seven guest lectures using quantitative and qualitative measures. Results show that students reported valuing these trainings with respect to each category, with the value to their professional careers being the highest ranked. This study shows students approve of learning leadership topics through guest lectures even when assigning varying degrees of value for each lecture and each of the three categories. However, students do not understand how these topics can relate to their project such that they can apply these trainings for the development of the skills. This study will help define better practices for leadership education within engineering curriculums to help determine whether providing leadership education concurrent to real-world experiences is effective.

Introduction

Developing leadership skills is accepted by industry, faculty, and students as an important part of the engineering curriculum for engineers starting their careers [1] - [3]. However, it is widely perceived that undergraduate engineering students lack leadership skills necessary for their careers [2], [4], [5]. The importance of learning teamwork and leadership while in school is reflected in the ABET General Criteria for engineering programs [6]. Integrating leadership trainings specifically into senior capstone courses is often used by academia to educate students on leadership, given it is the culminating curriculum work and they typically work in teams [7].

Team-based senior design courses rely heavily on collaboration and provide ample opportunity for students to practice the leadership skills they learn in these lectures. However, applying these skills requires that students also understand the implied value of developing these skills and can exemplify the development of these skills through their current team experience. Hence, the hypothesis is that students need to be motivated in order to actively pursue to develop leadership skills. This study explores whether students appreciate having leadership lectures taught by guest speakers with industry experience and if they think they learned valuable information from these lectures with respect to three categories: personal lives, professional careers, and the course objectives. The results from this study would provide context for further studies on student performance of leadership development.

Literature Review

Universities employ a variety of methods, such as lectures, in-class activities, and assignments, to give students opportunities to learn leadership skills [3], [4], [8] - [12]. Lectures are often utilized to provide leadership education to students [12]. Some programs invite guest speakers from industry and academia to teach these topics to students. Guest speakers are utilized to offer different leadership perspectives from industry professionals, learn directly from the pertinent topic representative, connect classroom learning with real world perspectives, and boost networking and communication skills for students [4], [9] - [11]. Guest lectures are a method presumed to be appreciated by students for reasons such as the qualifications of the guest and bringing diversity in teaching. The study in this paper provides results of measuring student perceptions for these events with respect to leadership development.

Multiple studies have assessed the effectiveness of engineering leadership programs in developing leadership skills and the consensus is that students and alumni report learning these skills through the lectures, in class activities, assignments and other experiences provided by these programs [1], [4], [8], [9], [13], [14]. Other studies have investigated in general what are the engineering student and alumni perceptions of the importance of leadership skills and the extent to which universities have prepared them to apply these skills professionally and found that they perceive leadership skills to be highly important for their careers though feel underprepared when starting their careers [3], [15], [16]. When investigating student perceptions of leadership skills, it is necessary determine if they understand the value of the trainings and recognize the opportunity to apply these lessons during their academic experience. One study looked at the students' perceptions of soft skills relative to learning or doing well in their present course of study, their future work or career, and how personally interested they are in developing each set of capabilities [17]. They found that students rated most skill areas as more relevant to their future work than their present course of study. In a similar perspective, the study in this paper measured engineering students' perceptions of leadership skills from the 3 categories of personal, professional, and present course of study.

Leadership skills have been identified by industry and higher education through a series of reviews and surveys. Some of the skills highlighted by industry and higher education as important to leadership are empathy and self-awareness, ethical conduct, appreciation of cultural diversity, work effectively in teams, and communication skills [3], [18]. The lecture topics for the study in this paper directly align with the leadership skills identified as important by industry and higher education.

The types of evaluation methods used in the studies described above are student reflections, peer and faculty feedback, student surveys and exit interviews, and alumni surveys [1], [4], [8], [9], [13], [14]. Student surveys have often been used after teaching events to self-report about the effectiveness of the lessons [4], [8], [9], [14]. Similar to the student perceptions studies described above, the study in this paper used a post-event student survey with a Likert scale [15], [17]. To provide context into the quantitative responses, each of those questions were followed by an open-answer question.

Research Questions

This study provides an analysis of how a group of students have valued leadership trainings with respect to three categories: the course objectives, their upcoming professional careers, and their personal lives. This study will support further research to answer the following questions:

1. How do engineering students value leadership trainings with respect to personal values, professional values, and academic development?
2. Are students motivated to learn and apply leadership skills during course experiences?
3. Are guest lectures with industry experience an effective method to teach leadership skills?
4. Are guest lectures with industry experience an effective method to motivate students to apply leadership skills in their projects and consider professional practice of these skills?

Context

Capstone design courses are the culminating experience for engineering students where they ideally put into practice all the knowledge and skills they have learned throughout their curriculum. This study collects data from students in the IPPD program, which offers a two-semester team-based multidisciplinary capstone design course where they work on a project in collaboration with faculty and industry sponsors, thus providing an opportunity to apply leadership skills in ways not possible with traditionally taught courses [19]. On these teams, students organize themselves into course defined roles related to team tasks such as team leader, meeting facilitator and finance coordinator. Students are encouraged to swap these roles so that each member can experience their preferred roles. Therefore, the course must also provide teamwork and leadership trainings. Most of these topics are offered by guest lectures from people in industry or academia who can share diverse perspectives and experiences.

For another research study done in the same capstone course, 28 out of 45 respondents, 62%, stated an interest in assuming a leadership role in their teams. This result suggests a majority of the students should have interest in leadership trainings.

Data Collection and Methodology

To determine the students' perceptions of the leadership lectures in the context of the three categories and in the context of the invited guest speaker, students were asked to complete a survey with 8 questions. The 8 questions were a combination of 4 quantitative questions with a Likert scale, each followed by a respective open-answer qualitative question. Table 1 shows a summary of the questions, and the Appendix section lists these as presented to the students.

The surveys were optional and anonymous except for the topic Elevator Pitch, which was shared as a graded participation quiz for the event. This quiz was shared before defining the uniform survey for this study. This quiz does not have corresponding qualitative questions for the first three categories. Students were informed that they would receive full credit just for submitting, regardless of content. This grade was equivalent to 0.47% of their course grade. All surveys were reviewed and approved by the Institutional Review Board. An additional one or two questions were tailored to each survey for the purposes of measuring their understanding of the lecture and

additional relevant impact, however, these were found to not have any impact on the analysis for this study.

Table 1. Survey Questions

Category	Quantitative Measure (Likert)	Qualitative Measure

Personal perspective, outside of engineering	You think lecture will help you:
	    1 is "not at all"
	    3 is "somewhat"
	    5 is "a lot"
		What you learned today is valuable to you outside of engineering

Professional engineer	You think lecture will help you:
	    1 is "not at all"
	    3 is "somewhat"
	    5 is "a lot"
		What you learned today will help you as a professional engineer

Project success	You think lecture will help you:
	    1 is "not at all"
	    3 is "somewhat"
	    5 is "a lot"
		What you learned today will help you towards completing your project successfully

Guest Speaker	Recommended for next year
	    1 is "no"
	    2 is "maybe if (explain below)"
	    3 is "for sure"
		Your thoughts on the score you gave

The senior capstone design course used in this study had a class of 59 students. The number of respondents for each survey and the guest lecture topics are provided in Table 2, in the order in which they were given during the two-semester duration of the course. Students were given about 15 minutes to complete these surveys in class at the conclusion of each guest lecture. The exception was the Engineering Leadership lecture given it concluded at the end of class time, so students were asked to complete it after class. The guest lecture topics are classified into two categories: leadership and non-leadership. The non-leadership topics were also surveyed and are used as a comparison to the leadership topics.

Table 2: Number of Respondents for Each Guest Lecture Survey

Guest Lecture Topic	Respondents	Category	Speaker Background
Elevator Pitch *quiz	58	Leadership	Industry & Academia
Scrum	54	Non-leadership	Industry & Academia
Emotional Intelligence	48	Leadership	Industry
Salary Negotiation	56	Non-leadership	Industry & Academia
Professional Credibility & the Standard of Care	49	Leadership	Industry & Academia
Engineering Leadership	40	Leadership	Industry
Inclusion, Diversity, and Implicit Bias	30	Leadership	Industry

Results and Analysis

Figures 1 through 3 show the results for respondents' perceptions of the value of the lectures with respect to a personal perspective outside of engineering, as a professional engineer, and project success. Figure 1, respective to a personal perspective, shows respondents overall gave high value to the leadership trainings, considering that over 70% of respondents gave a score of 4 or 5. These contrasts well with the responses for the non-leadership trainings where the Scrum lecture, a discipline specific technical topic, had the lowest value with 43%, and the Salary Negotiation lecture, a career development topic, had a relatively high value of 75%. Figure 4 discussed further below helps visualize these results.
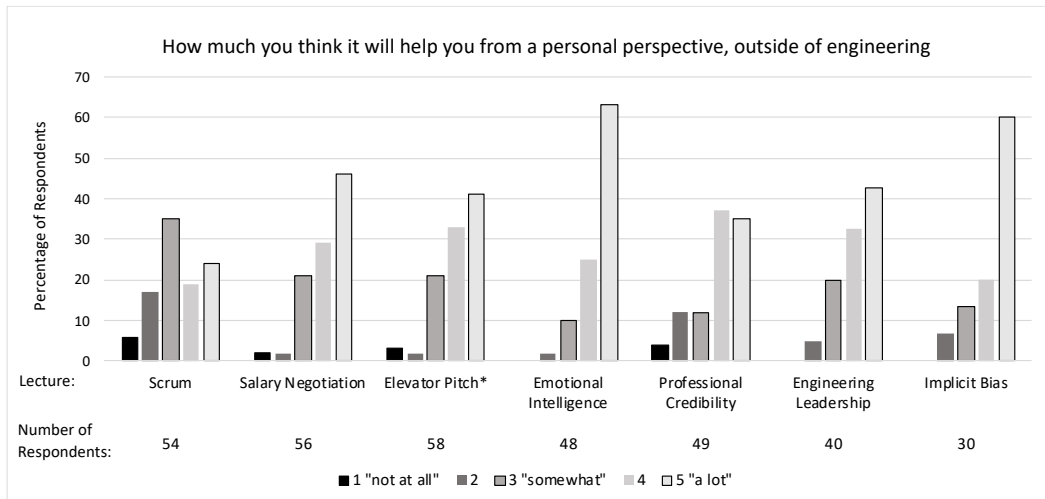

Figure 1. Respondents' perceptions of the value of the lectures with respect to a personal perspective

Figure 2, respective to a professional perspective, shows respondents overall also gave high value to the leadership trainings, with over 70% of respondents scoring with 4 or 5. These also contrast well with the non-leadership trainings where the Scrum lecture had a high value of 80%, while the Salary Negotiation lecture had a relatively low value of 66%.
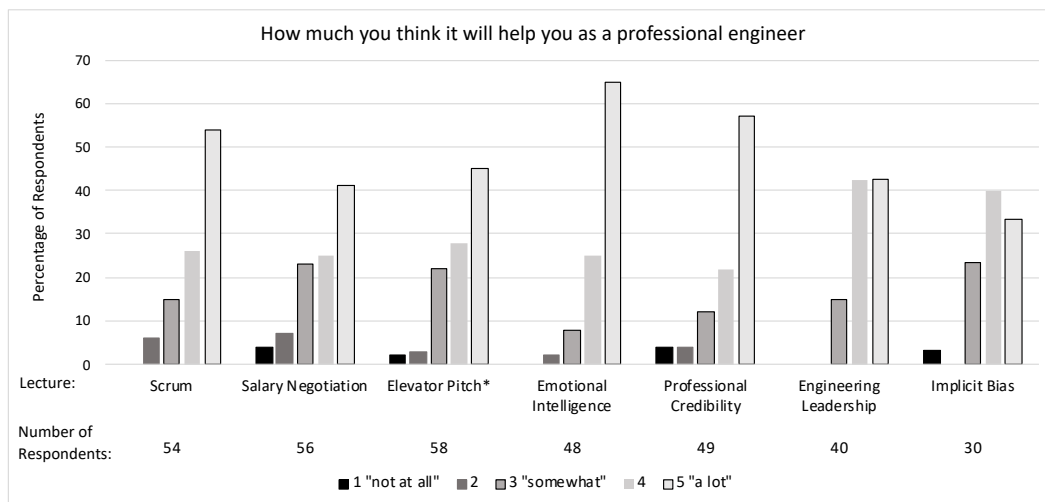

Figure 2. Respondents' perceptions of the value of the lectures with respect to a professional perspective

Figure 3, respective to the project perspective, does not show the same trend with responses to leadership trainings, with only one lecture having over 70% of respondents scoring a 4 or 5. In general, respondents had a mostly positive response for the question as the average result for each leadership training was (as ordered in Figure 4): 3.64 (EP), 4.30 (EI), 3.16 (PF), 3.23 (EL), 2.57 (IB). These leadership results contrast well with the non-leadership trainings where the Scrum lecture had the second highest score of 4s and 5s with 41% and an average of 3.89, while the Salary Negotiation lecture had the lowest score of 4s and 5s with 11% and an average of 2.09. Considering how was valued perceived, one respondent of the Salary Negotiation lecture commented that "*Although this is not directly related to the project I think it was useful in terms of how to communicate better with our coach and sponsor as difficult conversations arise.*"
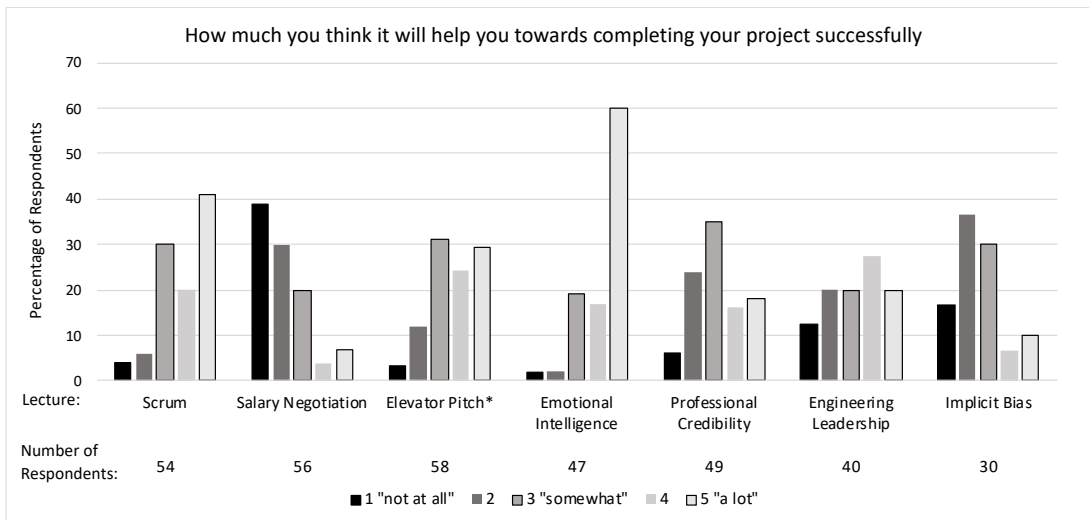

Figure 3. Respondents' perceptions of the value of the lectures with respect to the course project

Figure 4 shows the results of 4s and 5s for each lecture with respect to each of the three categories.
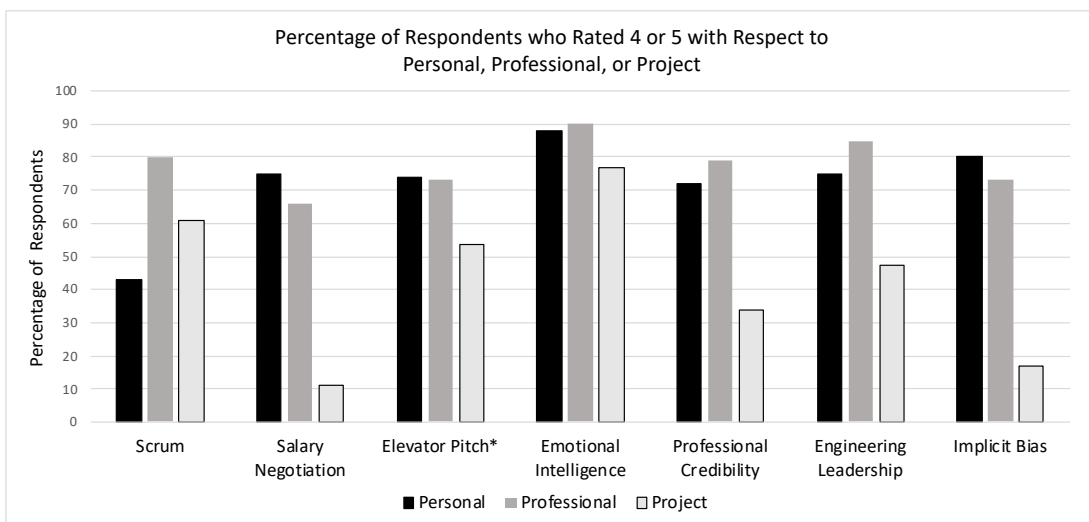

Figure 4. Respondents who selected 4 and 5 when rating how much what they learned in the guest lecture presentation would be helpful with respect to each of the three categories

The most highly valued lecture topic with respect to project success was Emotional Intelligence. Overall, the respondents really appreciated this topic for a few reasons, exemplified through the quotes below.

- *"Being able to work well with my team is extremely important to our success, and being aware of these topics hopefully will help us."*

- *"When we initially got placed in these groups, we were working with strangers that we had never worked with before. As such the ability to develop interpersonal relationships, and understand how our team members are feeling will be vital to working together as a cohesive team."*

- *"There hasn't been a situation where we have had issues but if such a case happened (and threatened the success of our project) using the information learned today we could mitigate the problem and learn from it."*

Conversely, the other four leadership topics were not valued with respect to project success to the same level as the Emotional Intelligence lecture was valued. Overall, respondents described how they do not understand how these topics can relate to their project. Representative quotes from the five leadership lectures are listed in Table 3.

Table 3: Select Responses from the Five Leadership Lectures Regarding Low Project Ratings

Elevator Pitch	"While I think the relation of elevator pitches to the presentations required for this class is somewhat fuzzy, elevator pitches have many other applications outside of this class and are a useful skill for any student, worker, or entrepreneur to have."
Emotional Intelligence	"I think a lot of the concepts in this presentation can't really be learned in this kind of lecture format, they come with personal experience."
Professional Credibility	Example 1: "I don't foresee any ethical issues in our project."
	Example 2: "Not really applicable to our software based project."
Engineering Leadership	"Some leadership advice could be used in our team project, but lots of the advice is more relevant to industry and not totally applicable to the project."
Implicit Bias	"I do not think focusing more on diversity and inclusion will have an affect [sic] on how successfully or quickly our team completes our project."

The results show that a significant portion of the class does not clearly relate the leadership skills to the current project experience. Following the concern of their skills level at graduation, the question remains of how to help students apply these skills during the course. Possible reasons include the timing of the lesson, the context in which the lesson was delivered, the speaker of the day or the current situation within their project experience. It is also possible, though not explicit in the results, that students interpreted the question with respect to building their prototype rather than completing a successful project with respect to all the evaluations, which include teamwork, communication, and other professional skills. Regarding the timing and context of the lecture, perhaps having these trainings in a previous course would help students to apply these skills

from the beginning of the project. This can be reflected through some of the respondents' comments in the survey. For example, in response to the Engineering Leadership lecture, two respondents stated that *"At this late stage in our project I think that the way our team interacts is set in stone"* and *"I think this would be beneficial in the beginning of IPPD."*

Regarding the lecture speaker, Figure 5 shows the results for respondents' recommendations on whether the speaker should return to this course next year for the respective lecture. For all lecturers, over 70% of the respondents said yes.
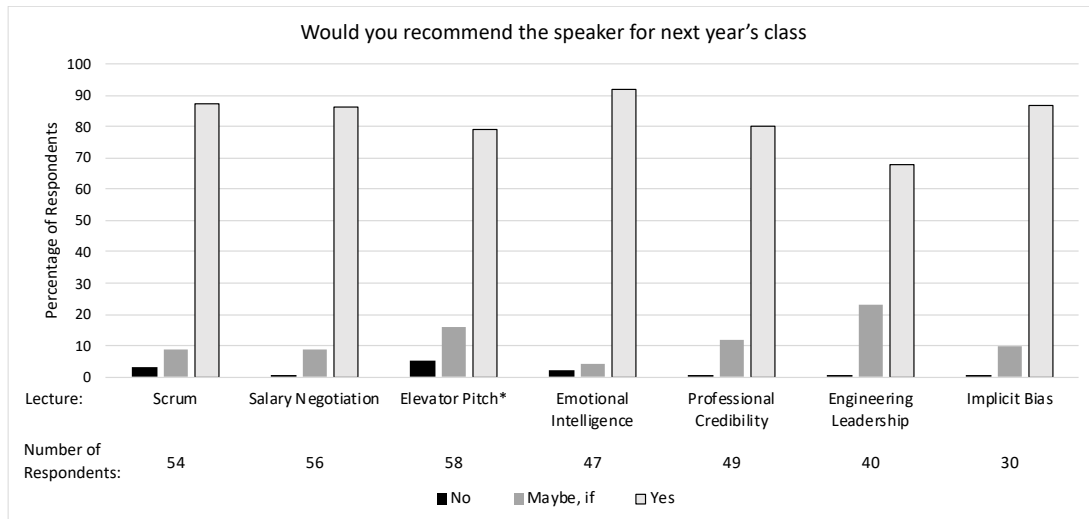

Figure 5. Respondents who recommended the speaker returns next year for the respective lecture

These results suggest that having guest lectures with industry experience is an effective method for delivering leadership topics, which is in line with the literature that describes students appreciate learning through guest lectures in general. A few respondents would literally state this benefit with comments such as *"I think it was very beneficial to hear from someone in industry about how important emotional intelligence is in the workforce today."*, *"It was good to have some insights from someone who has industry experience and share his thoughts."*, *"…it was interesting to hear from professionals from the industry and learn tips from them."*.

Reviewing the connection between appreciation for the speaker and the perception of value from each lecture, Figure 6 shows the responses from Figure 4, that is, respondents who rated 4 or higher for the personal, professional, and project perspectives, but filtered by respondents who gave positive comments for the speaker with respect to their presentation, engagement, or usefulness of topic. For each lecture except Engineering Leadership, over 60% of respondents gave a score of 4 or 5, and gave a positive comment about the speaker in at least one of the three categories. Emotional Intelligence was the only lecture that had over 60% respondents with respect to all three categories. Overall, the evidence suggests a positive correlation between speaker satisfaction and perceived value of the topic.
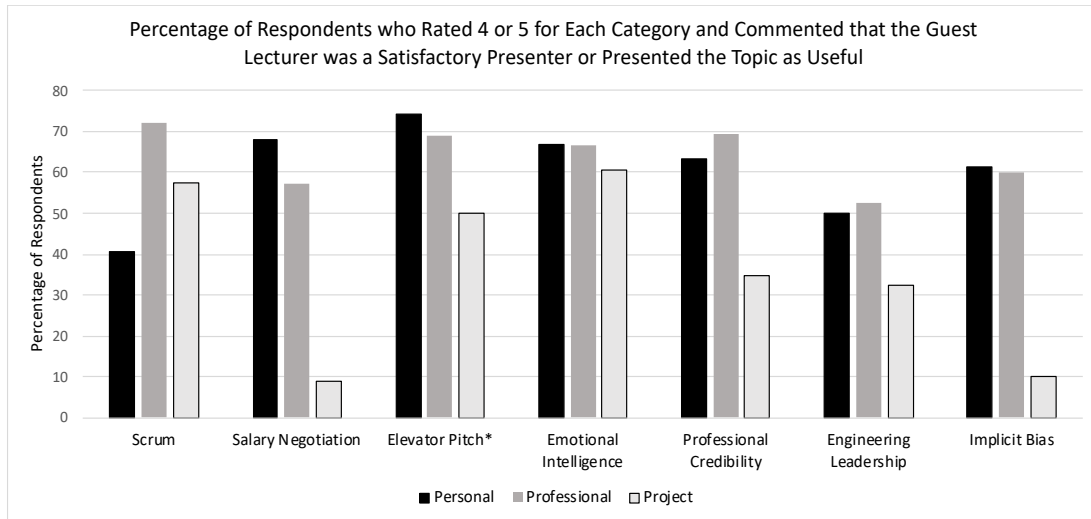
Figure 6. Respondents who rated as 4 or 5 the categories of each lecture and commented that the speaker was satisfactory or presented the topic as useful, that is, who appreciated the lecture and lecturer.

Reviewing the comments for the speaker of the Engineering Leadership lecture shows most respondents were dissatisfied with the quality of the presentation. The representative comments from these responses are highlighted below.

- *"The content was very dry, and I personally felt like the content did not stretch past content we have seen in past guest lecturers."*

- *"Maybe tailor the discussion more towards our project and advice on working in a group dynamic."*

- *"The lecture went long."*

Evaluating the responses of all leadership lectures from those who stated they do not recommend or would maybe recommend the speaker for next year's class, their reasons can be summarized into three types of categories: (1) They did not approve of the speaker's performance for reasons such as how the topic was presented, presentation was lacking in depth of topic, the speaker was too dry or the event went too long; (2) they did not think the topic was relevant for the course; or (3) they have already learned this topic many times. Since not all students valued learning these topics with respect to the three categories, it is expected that some students would not recommend speakers based on the relevance of the topic. Not recommending the speakers due to their performance or topic delivery highlights the need to ensure speaker preparation with respect to topics of interest for the students and delivering within a context that aligns with their course needs.

This study shows that students value leadership trainings with respect to personal values, professional values, and academic development. The results show that students approve of these guest speakers for the discussion of these leadership topics even as they have assigned varying degrees of value to the lecture topics. However, while they were motivated to learn through the guest lectures and saw value in each lesson, they were not motivated to apply these skills in their current project. The results suggest most students did not relate with the opportunity to apply

these lessons through their project experience. A next step for this research could be to explore this question through student reflections and post-experience evaluation exercises.

Future Work

For the remainder of the Spring Semester with this same course of students, 4 additional guest lectures will be given, with 3 of these in the topic of leadership. These lectures will also be surveyed and the data will be aggregated to verify the current conclusions. The research plan is to continue with a multi-year, multi-course plan to examine the student perspective of the need and value of engineering leadership during their education. All this data will provide an outlook of how students perceive the value of leadership lectures and support a list of guidelines for improving the effectiveness of these lectures towards having students develop their leadership skills during team-based courses.

A critical question that requires further study is why is there a disconnect between the perceived value for projects and professional experience, if these projects are sponsored and guided by industry liaison engineers? Further emphasis must be placed with guest speakers and the context of the current situation of students within their project experience. Another new research question is to investigate if the students who seek leadership positions within their project team are more likely to value these lectures in the context of their projects.

The knowledge of how students perceive leadership trainings as a foundation for providing students the best opportunities to apply and develop these skills, will allow further research to improve the effectiveness of the applied value of these trainings. Specifically, will the increase in student motivation and their opportunities to apply these skills, will students be more adept at developing these skills?

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Appendix

Survey shared with students after each guest lecture.

Question 1
On a scale of 1 through 5, rate the lecture based on how much you think it will help you from a personal perspective, outside of engineering, where
1 is "not at all"
3 is "somewhat"
5 is "a lot"

Question 1a
Comment on how what you learned today is valuable to you outside of engineering

Question 2
On a scale of 1 through 5, rate the lecture based on how much you think it will help you as a professional engineer, where
1 is "not at all"
3 is "somewhat"
5 is "a lot"

Question 2a
Comment on how what you learned today will help you as a professional engineer.

Question 3
On a scale of 1 through 5, rate the lecture based on how much you think it will help you towards completing your project successfully, where
1 is "not at all"
3 is "somewhat"
5 is "a lot"

Question 3a
Comment on how what you learned today will help you towards completing your project successfully.

Question 4
On a scale of 1 through 3, do you recommend this speaker for next year's class, where
1 is "no"
2 is "maybe, if" (answer in question 5)
3 is "for sure"

Question 5
Describe your thoughts on the score you gave for the previous question.

The following set of questions are for the one instance shared as a quiz instead of survey.

Question 1
On a scale of 1 through 5, rate how much do you value what you learned today, where
1 is "not at all"
3 is "somewhat"
5 is "a lot"

Question 2
On a scale of 1 through 5, rate the lecture based on how much do you think it will help you as a
professional engineer, where
1 is "in nothing"
3 is "likely"
5 is "for sure"

Question 3
On a scale of 1 through 5, rate the lecture based on do you think it will help you towards
completing your project successfully, where
1 is "in nothing"
3 is "likely"
5 is "for sure"

Question 4
On a scale of 1 through 3, do you recommend this speaker for next year's class, where
1 is "no"
2 is "maybe, if" (answer in question 5)
3 is "for sure"

Question 5
Describe your thoughts on the score you gave for the previous question.